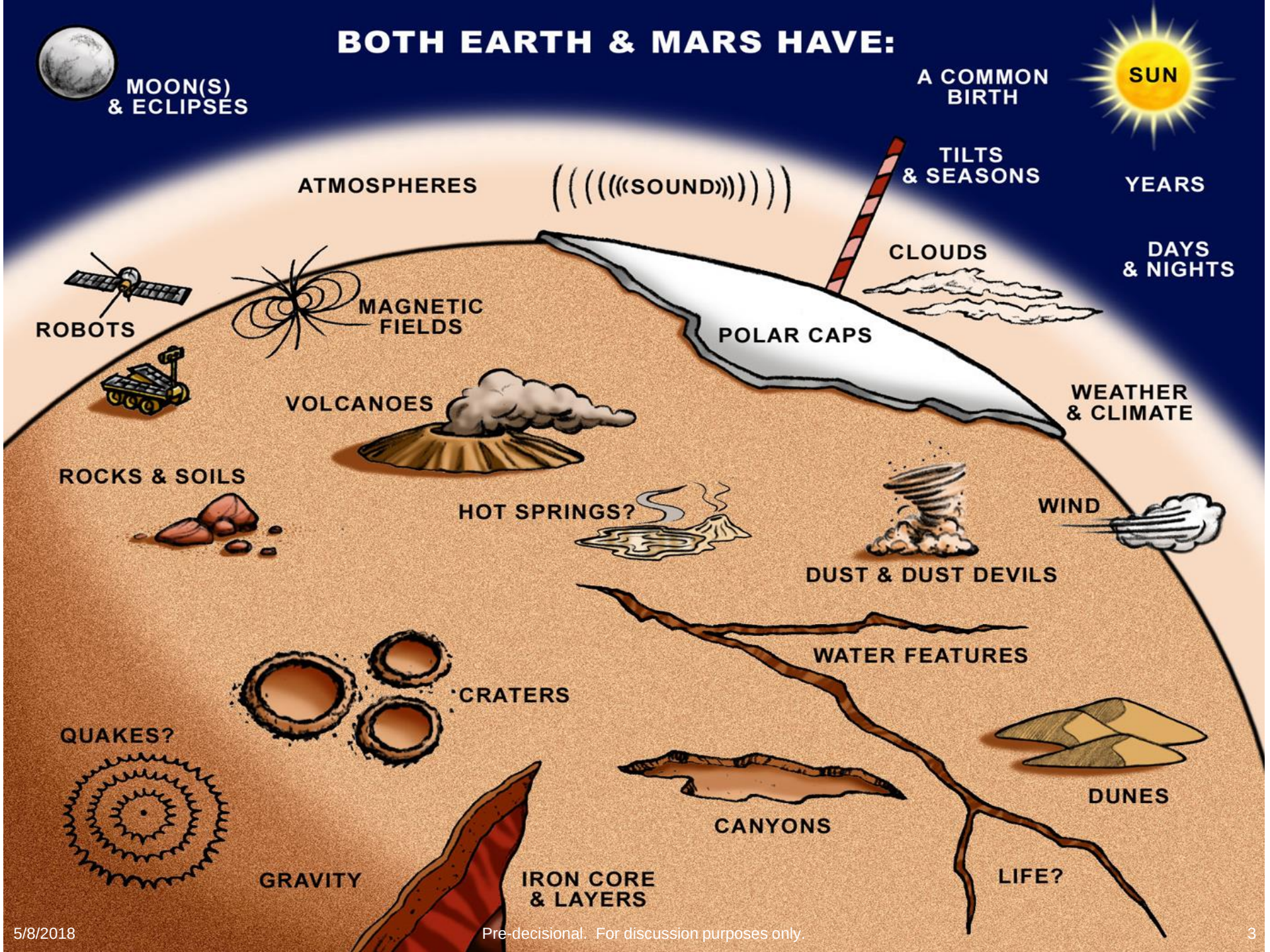
Concepts for Future Human Exploration of Mars

Hoppy Price
NASA Jet Propulsion Laboratory
California Institute of Technology

Presentation at the National Air & Space Museum
Washington D.C.
May 8, 2018

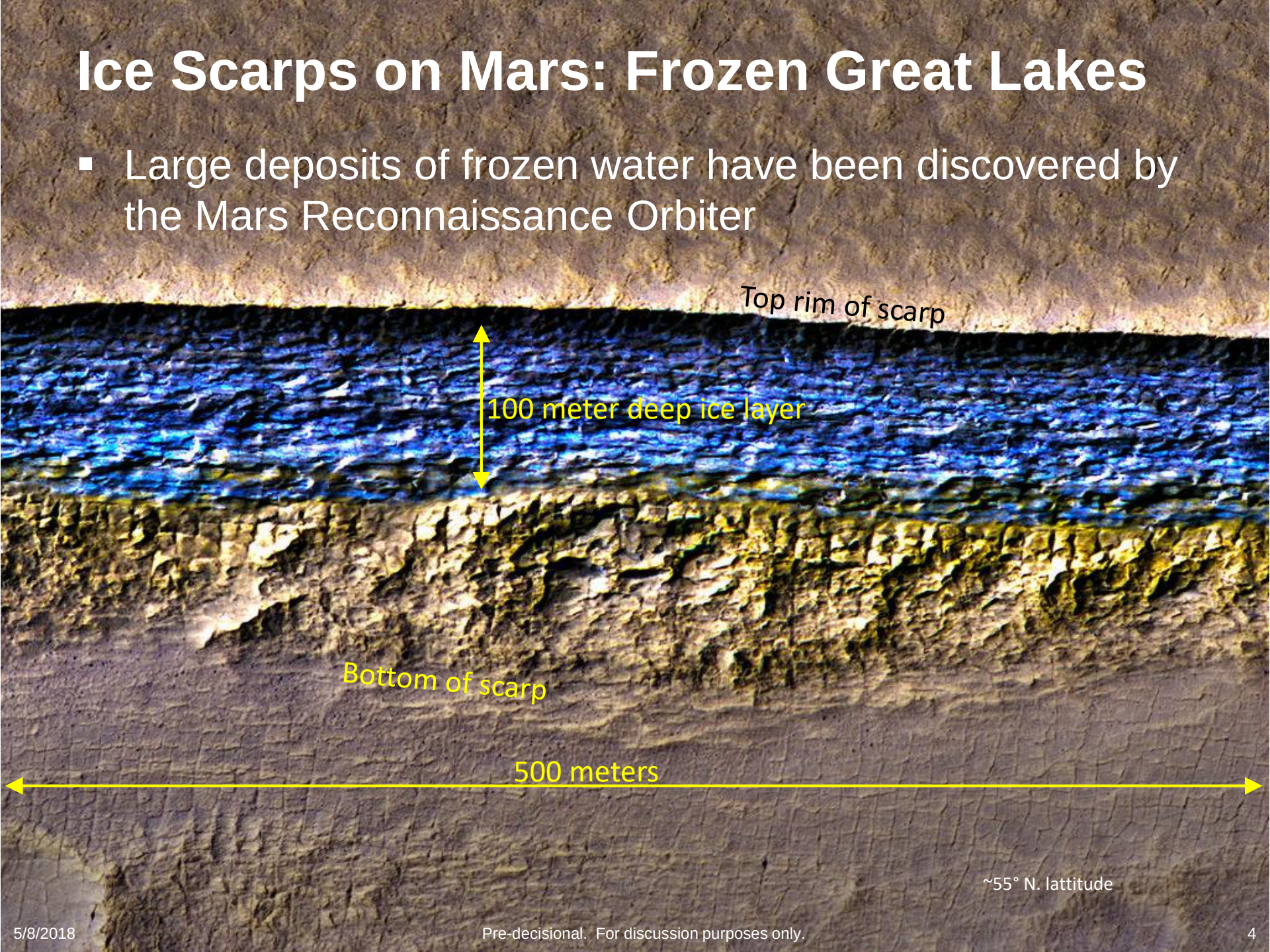
Why Mars?

- **Mars science is compelling**
  - Mars was Earth-like over 3 billion years ago
  - Possibility of discovering fossils of extinct microbial life
  - Possibility of discovering current microbial life underground
  - Humans on-site would be more expedient than robots
- **Mars is the most hospitable planet beyond Earth that is accessible**
  - 24.7 hour day
  - Closest gravity to Earth (~1/3 g)
  - Water ice glaciers just under the surface
  - CO_2 atmosphere as a readily available resource

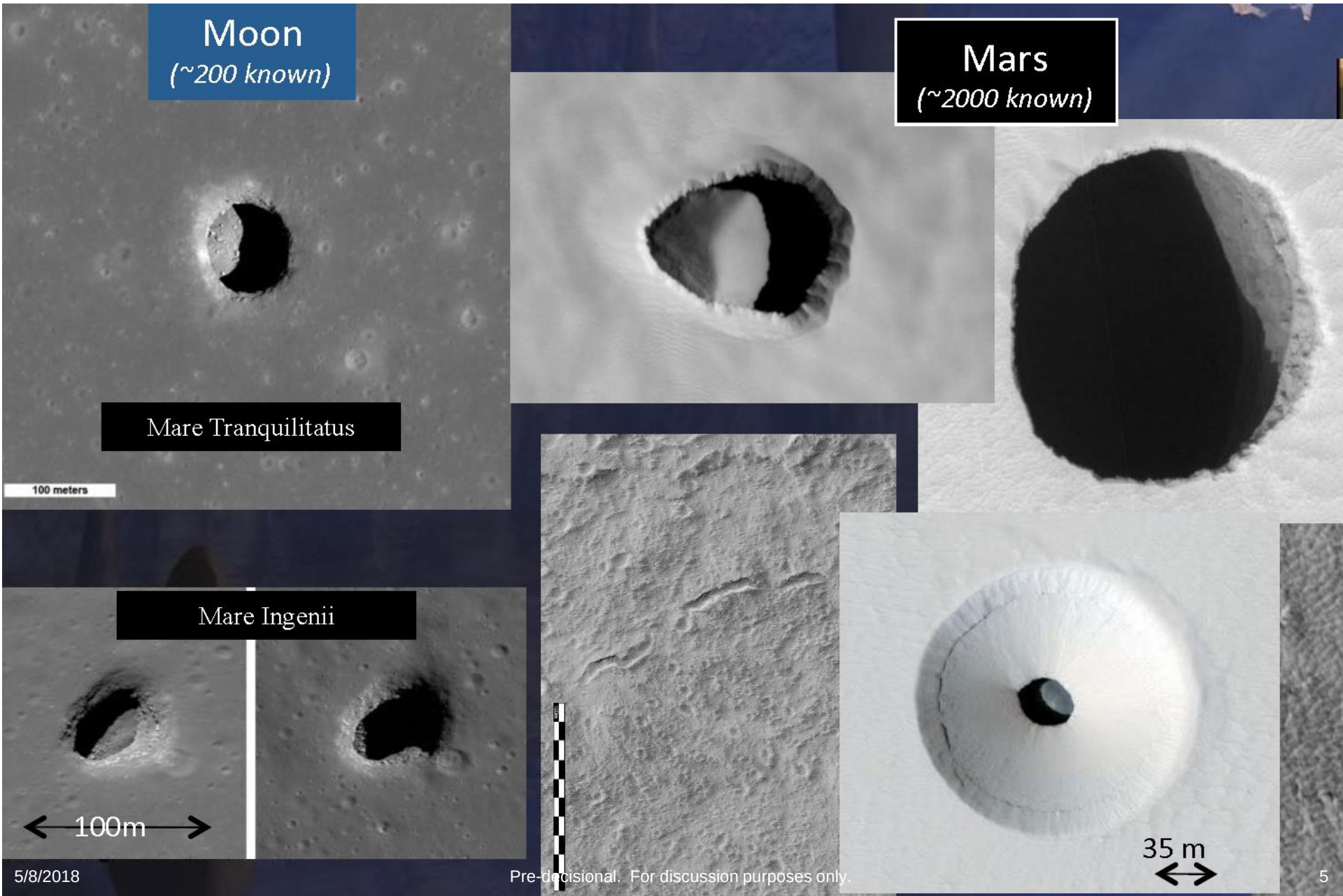


Ice Scarps on Mars: Frozen Great Lakes

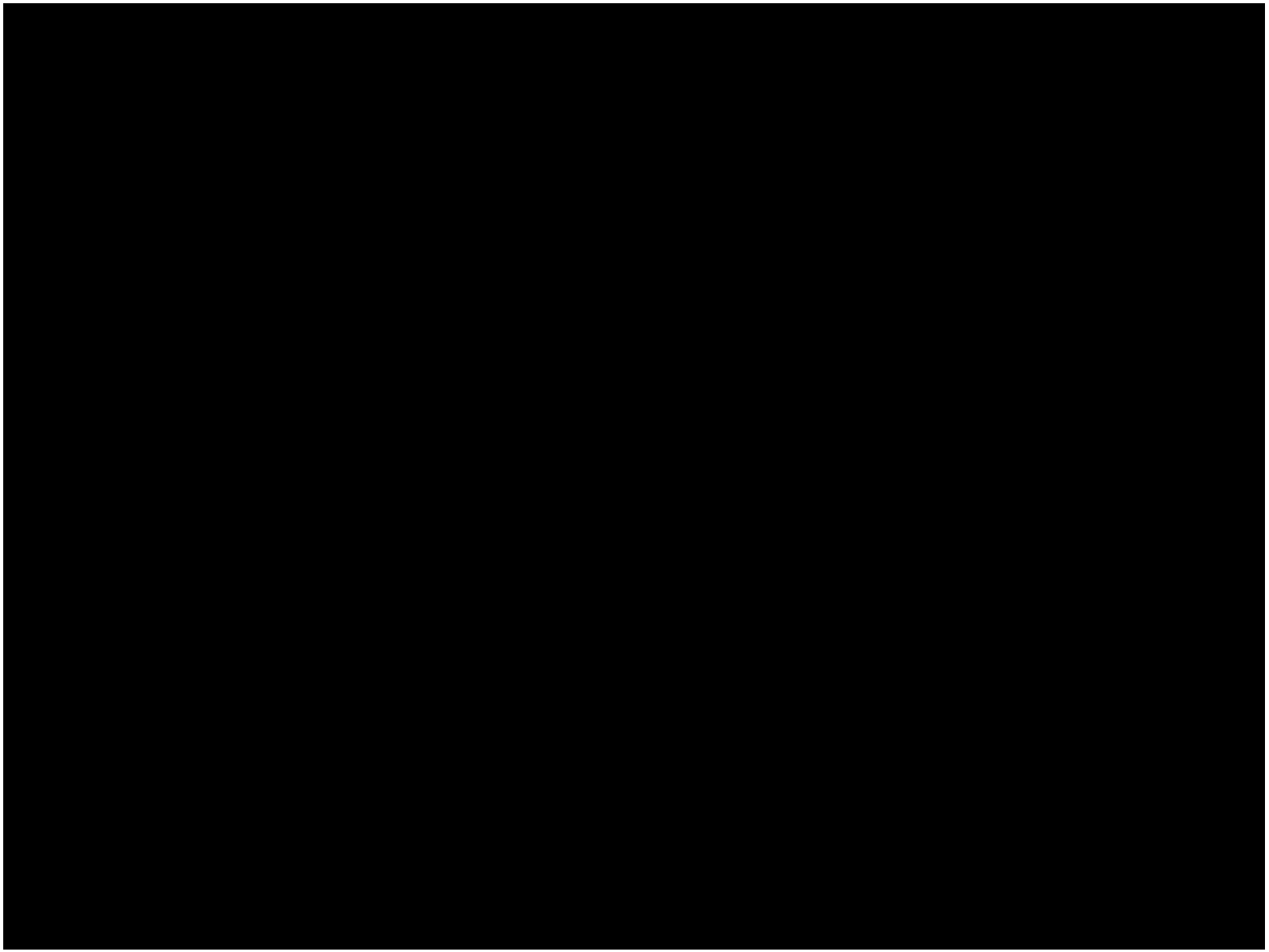
- Large deposits of frozen water have been discovered by the Mars Reconnaissance Orbiter



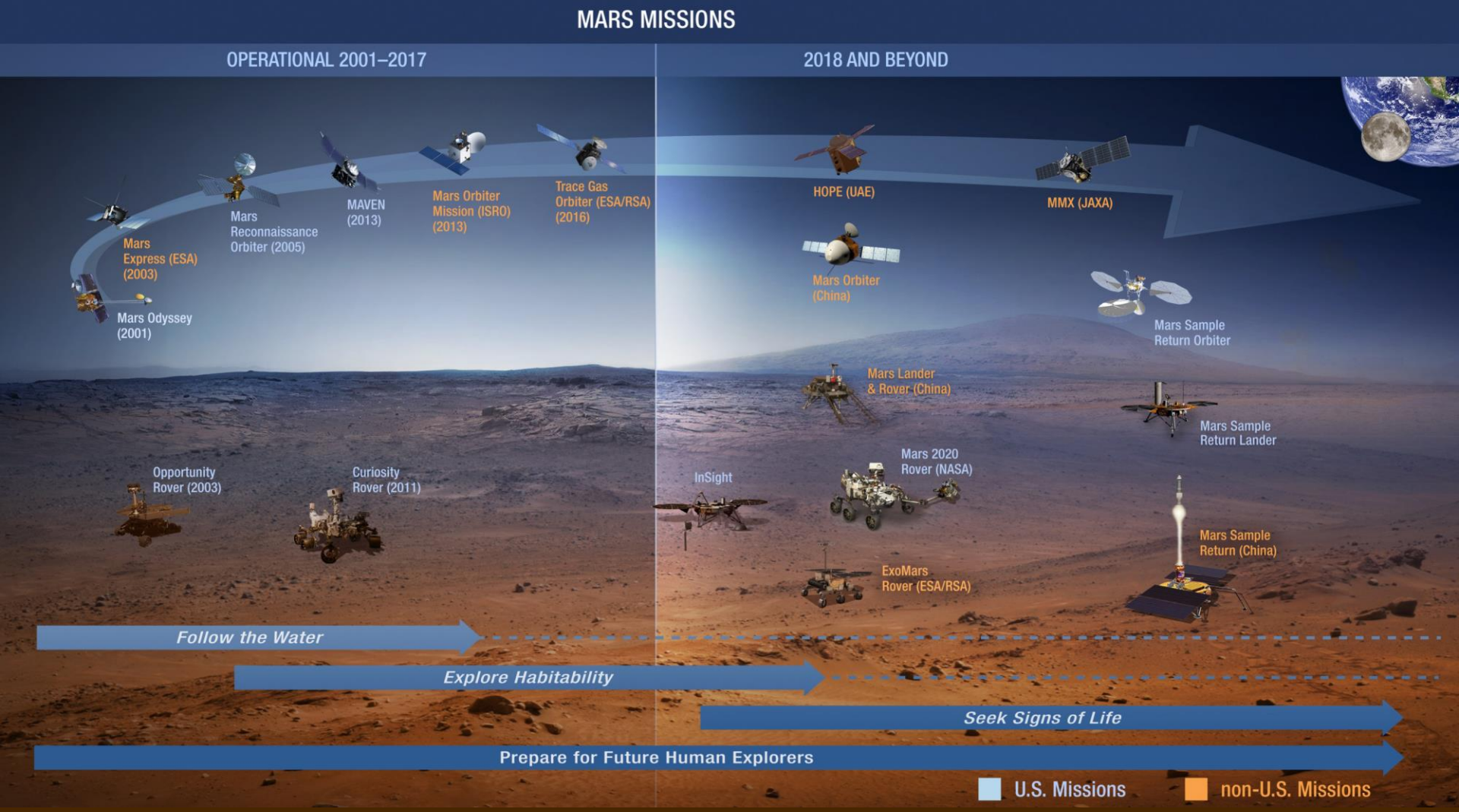
Caves on the Moon and Mars: Yet to be Explored



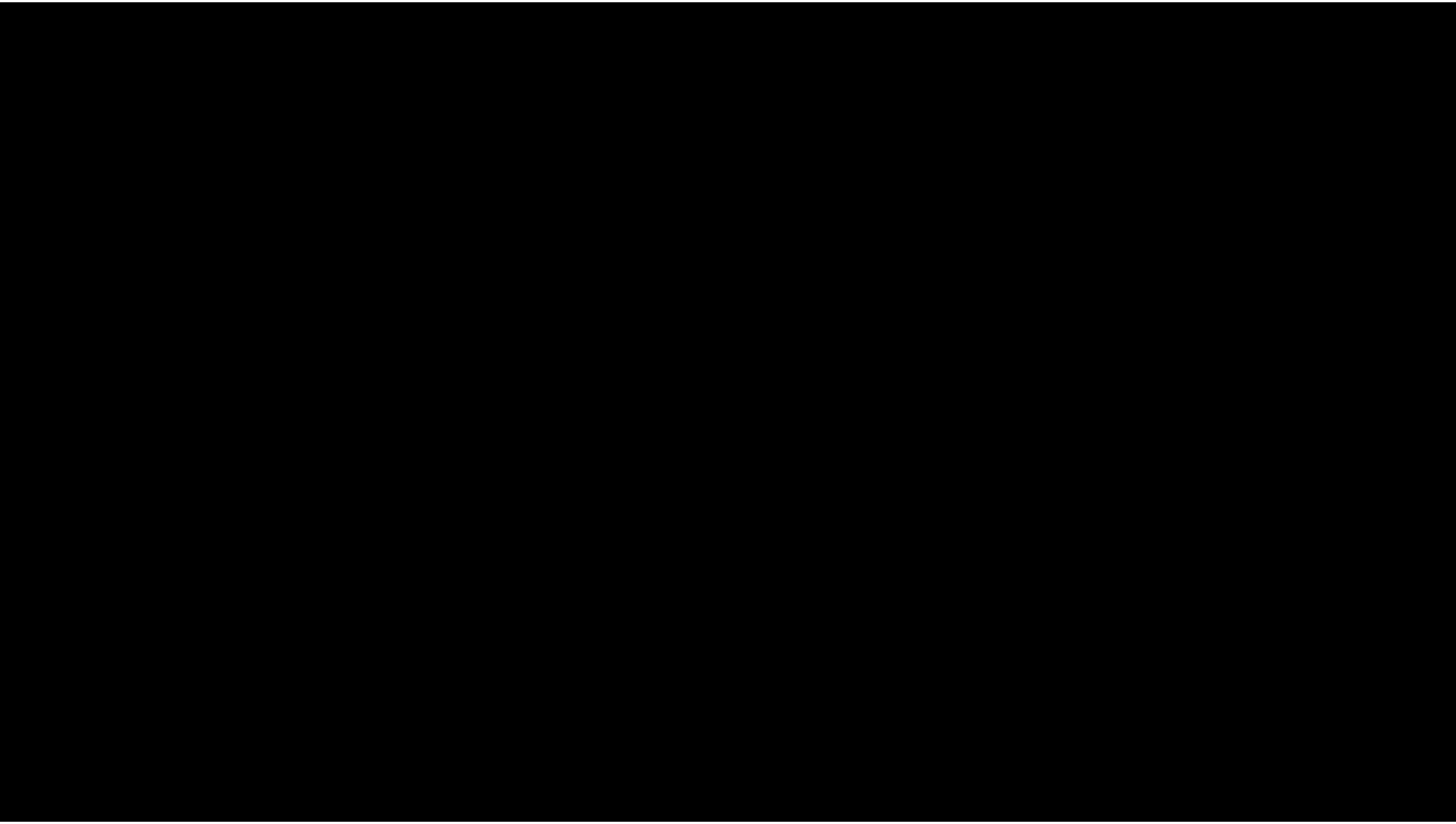
Axel Rover: Getting to Hard to Reach Places



Robotic Exploration Missions



Mars Sample Return Concept



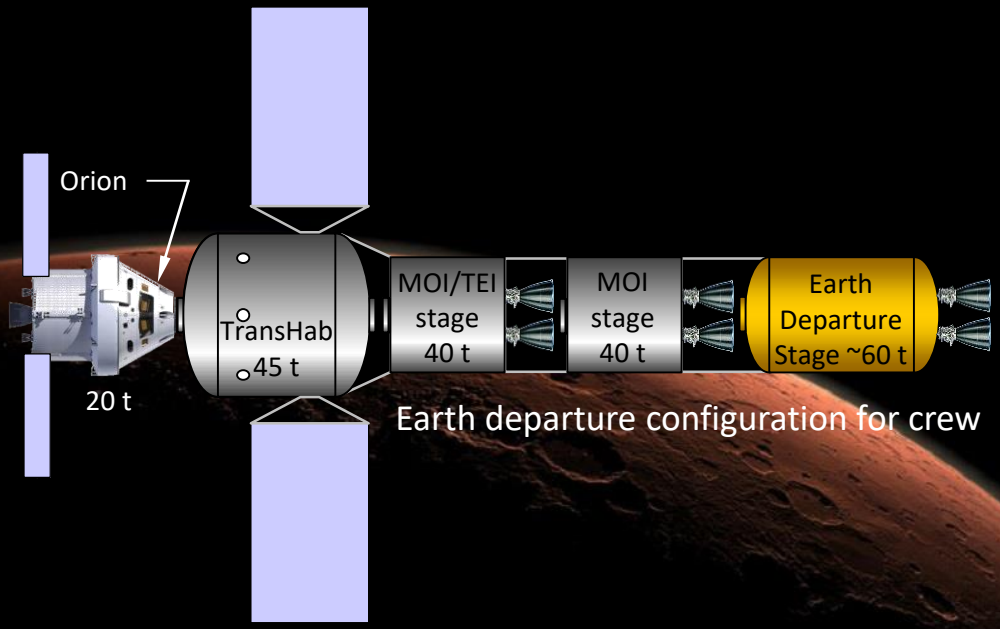
Mars 2020 Rover Currently Under Construction

Sky Crane landing system

NASA/JPL Caltech

Going to Mars in 2033: Transit Vehicle Concept

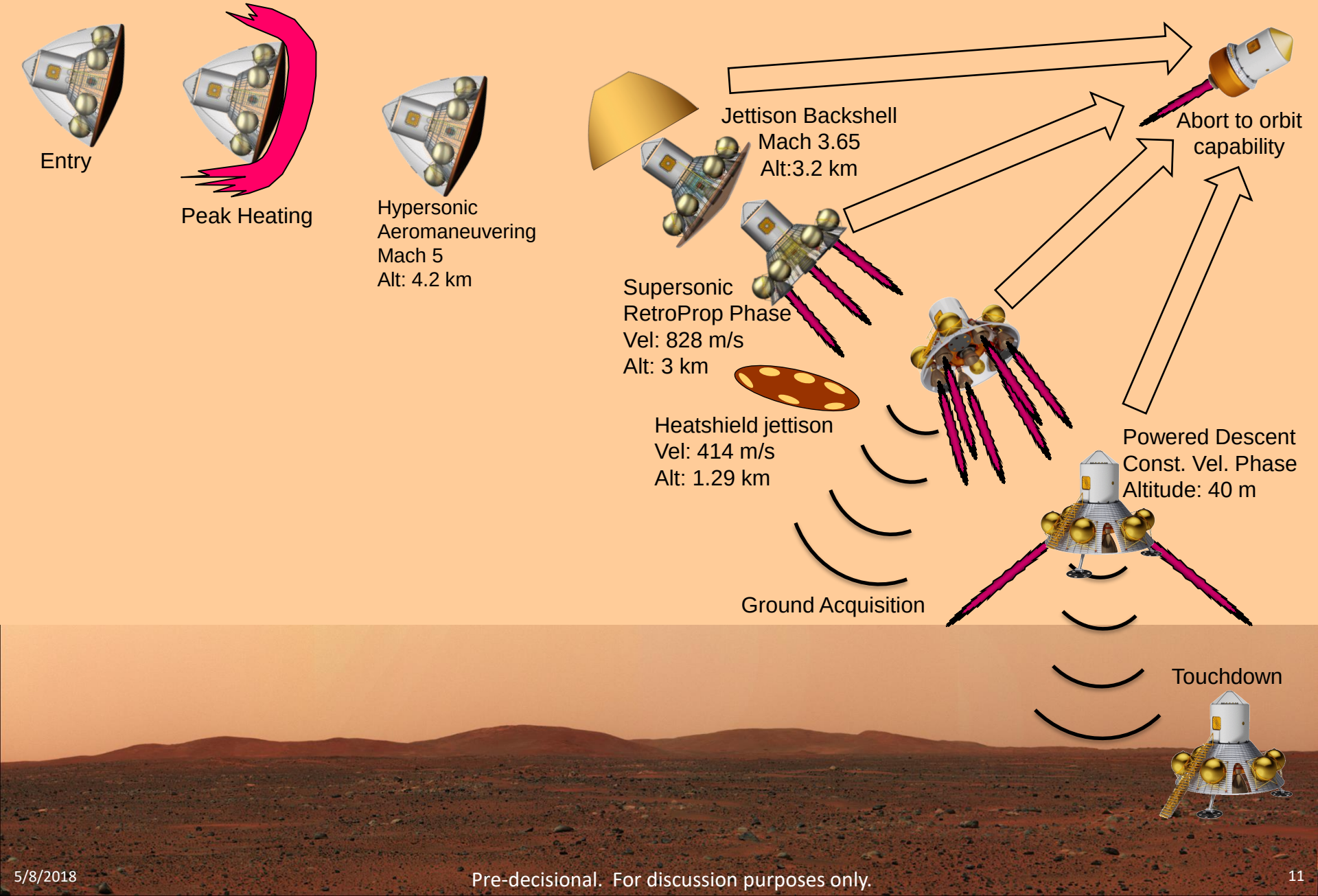
- There are many viable concepts for vehicles to transport crews to Mars and back
- A recent workshop with Mars experts (Explore Mars AM V) developed three different “community” architectures with different assumptions of complexity and capability
  - 1) sortie exploration missions, 2) field camp, 3) permanent presence
- This is an example of the lower cost, sortie option



Earth departure configuration for crew

- Design would first be tested in lunar orbit
- Launched in segments by SLS and commercial rockets
- Assembled in high Earth orbit
- Crew would return to Earth in Orion capsule

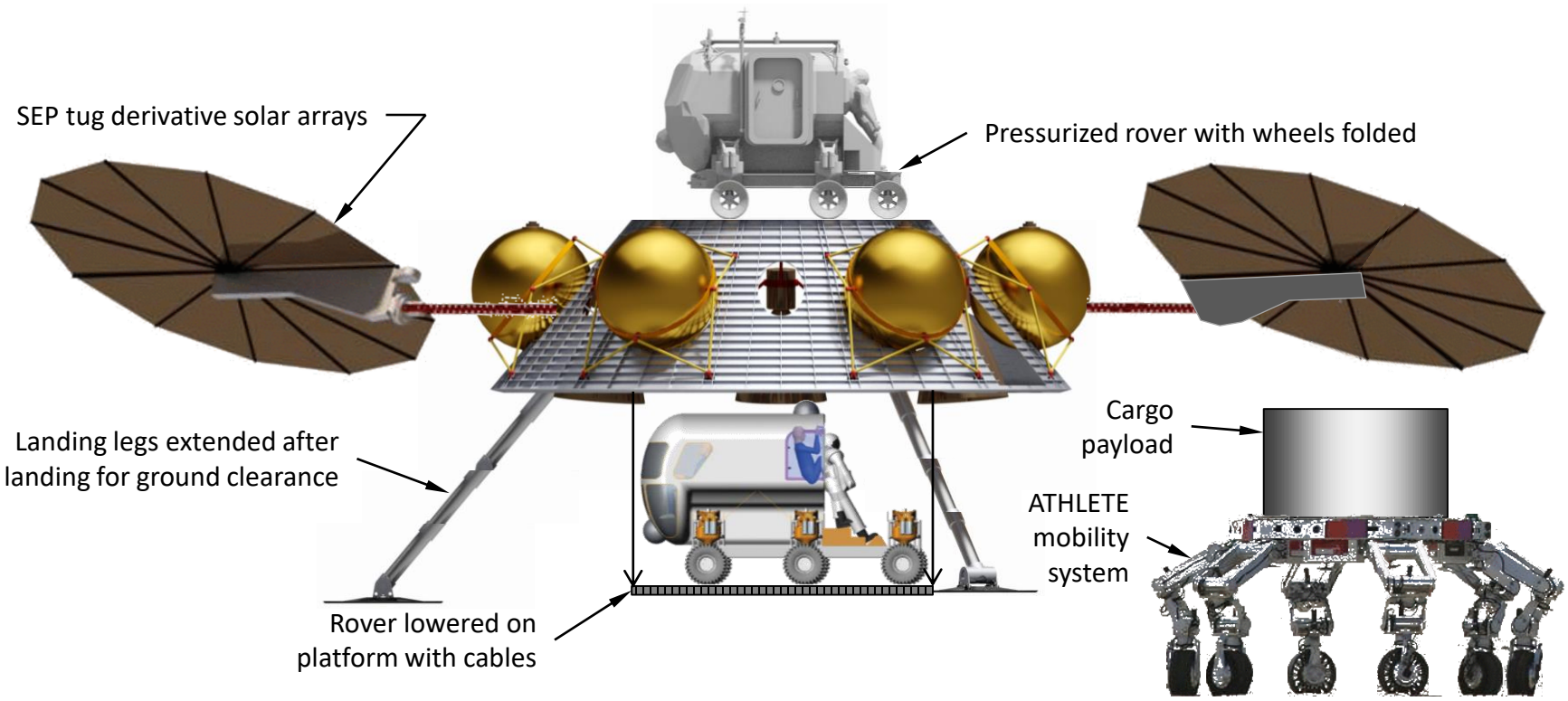
Entry, Descent, and Landing (EDL) Concept for Crewed Mars Lander



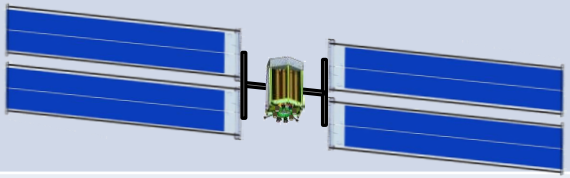
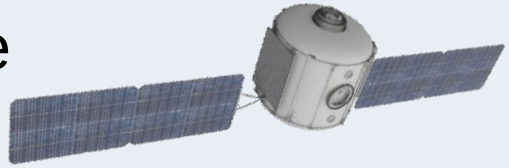
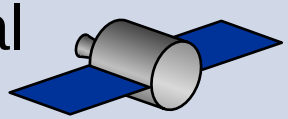
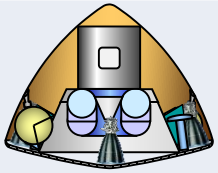
Mars Short Surface Stay Mission
Concept for First Crew on Mars

Mars Cargo Logistics Lander Concept

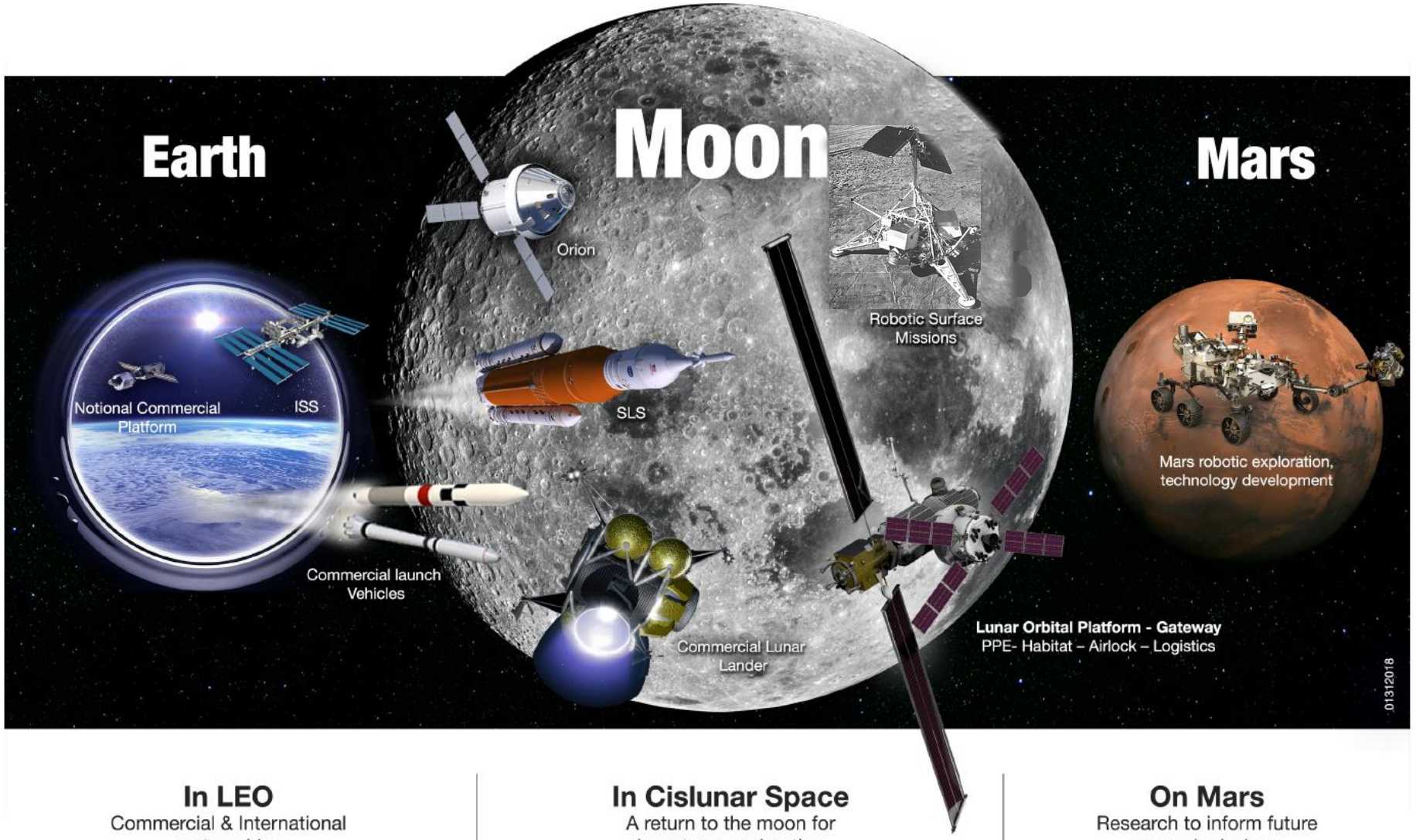
for extended exploration and longer stay times in later missions



Six Vehicles to Enable Crewed Missions to Mars

Vehicles	# Vehicles per Mission	
Orion 	1	In development
SLS 	5	In development
SEP Tug ~125 kWe 	1	Studies are on contract
Deep Space Habitat 	1	Studies are on contract
In-Space Chemical Propulsion Stage 	4	Could be an international contribution
Mars Lander 	1	Development would need to start soon

NASA's Current Plans for Human Exploration



In LEO
Commercial & International partnerships

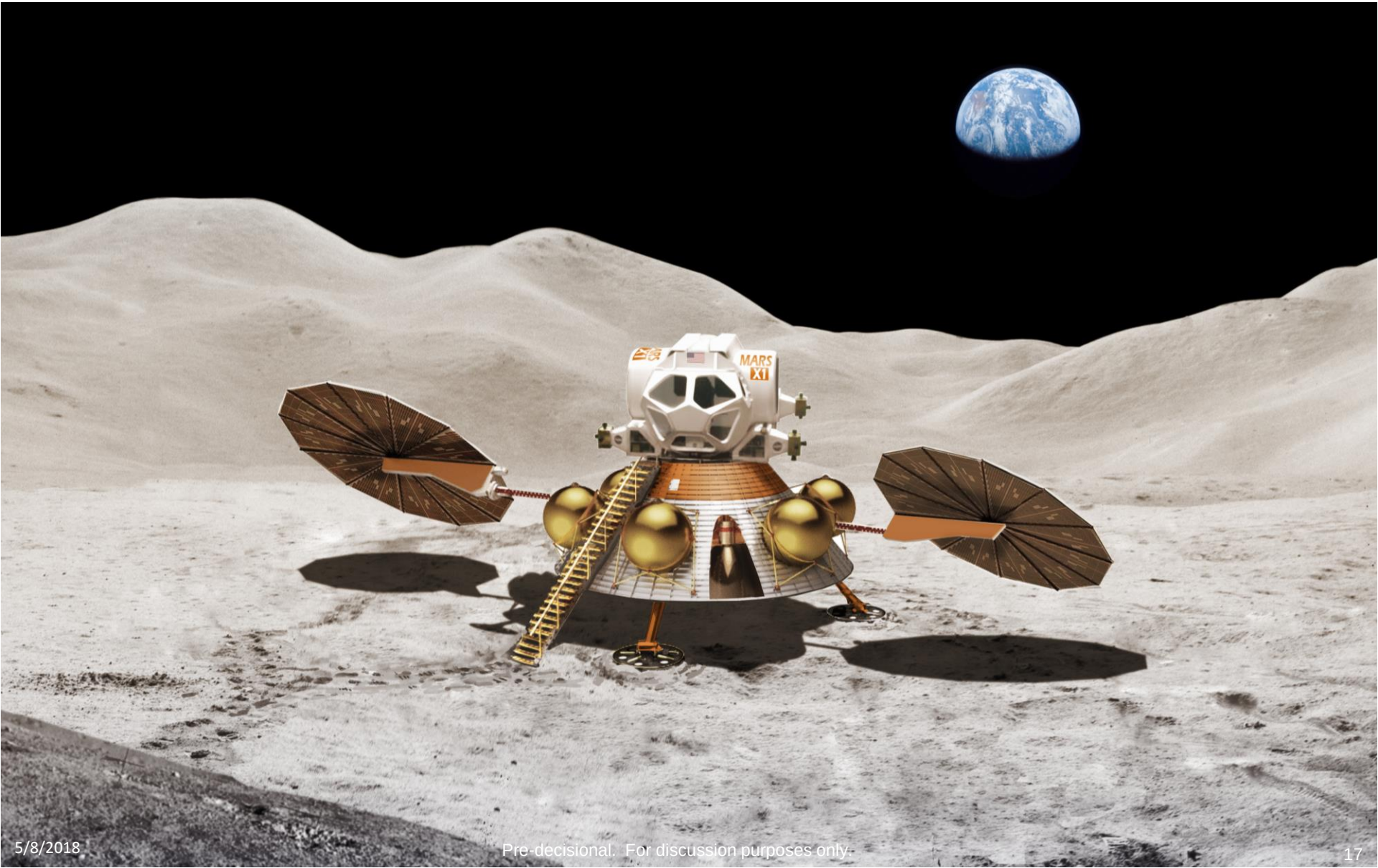
In Cislunar Space
A return to the moon for long-term exploration

On Mars
Research to inform future crewed missions

The Moon on the Path to Mars

- The Moon could provide important testing and qualification of the vehicles to conduct successful missions to Mars
  - Orion
  - Deep Space Habitat
  - Mars lander and Mars Ascent Vehicle (MAV) system checkout
  - Mars orbital and surface operations and Earth ground operations
- The Moon could provide a shakedown test of the lander design
  - Qualify design in crewed flight-like environment
  - System qualification, space operations, terminal descent and landing, surface deployments, crew surface operations, and MAV operations

Concept for Crewed Test of Mars Lander on the Moon



Mars is in our future for both robotic and human exploration